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(12) UK Patent Application (19) GB (11) 2 308 746 (13) A

(43) Date of A Publication 02.07.1997

(21) Application No 9626369.4

(22) Date of Filing 19.12.1996

(30) Priority Data
(31) 07344257 (32) 28.12.1995 (33) JP

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(51) INT CL^6
H01Q 1/24 9/30 , H04B 1/38

(52) UK CL (Edition O)
H1Q QHC

(56) Documents Cited
GB 2296603 A GB 2213998 A EP 0688060 A1
US 5446469 A

(58) Field of Search
UK CL (Edition O) H1Q QHC QHX QKC
INT CL^6 H01Q 1/08 1/10 1/22 1/24 9/30 , H04B 1/38
Online: WPI

(54) Portable radio device antenna apparatus

(57) A portable radio device antenna apparatus has a retractable antenna element (20) mounted on the casing (10) of a radio device. The antenna element includes a straight element (21) having an electrical length of $\lambda/2$ and a helical coil (22) having an electrical length of $\lambda/4$ and attached to the upper end of the straight element. The casing contains an impedance matching circuit (11) having a pair of terminals (A, B) and serving to perform impedance matching of the straight element. When the straight element is pulled out from the casing, a feeding metal piece (14) connected to a radio circuit (15) and an inner connection metal piece (13) connected to one terminal (B) of the impedance matching circuit are simultaneously connected to a metal fixture (26) of the antenna element, and an outer connection metal piece (12) connected to the other terminal (A) of the impedance matching circuit is brought into contact with the straight element (21). When the straight element is retracted (Fig 1B, not shown), the feeding metal piece (14) is brought into contact with a metal fixture (27) connected to the helical coil, and the inner and outer connection metal pieces (13, 12) are respectively brought into contact with an insulator (23) between the straight element and the helical coil and a protective cover (28) which covers the helical coil, such that the radio circuit (15) is connected to the coil only.

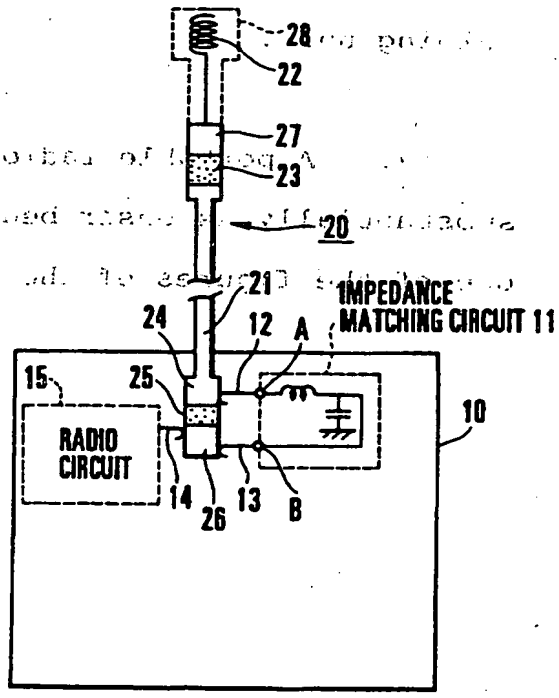

FIG. 1A

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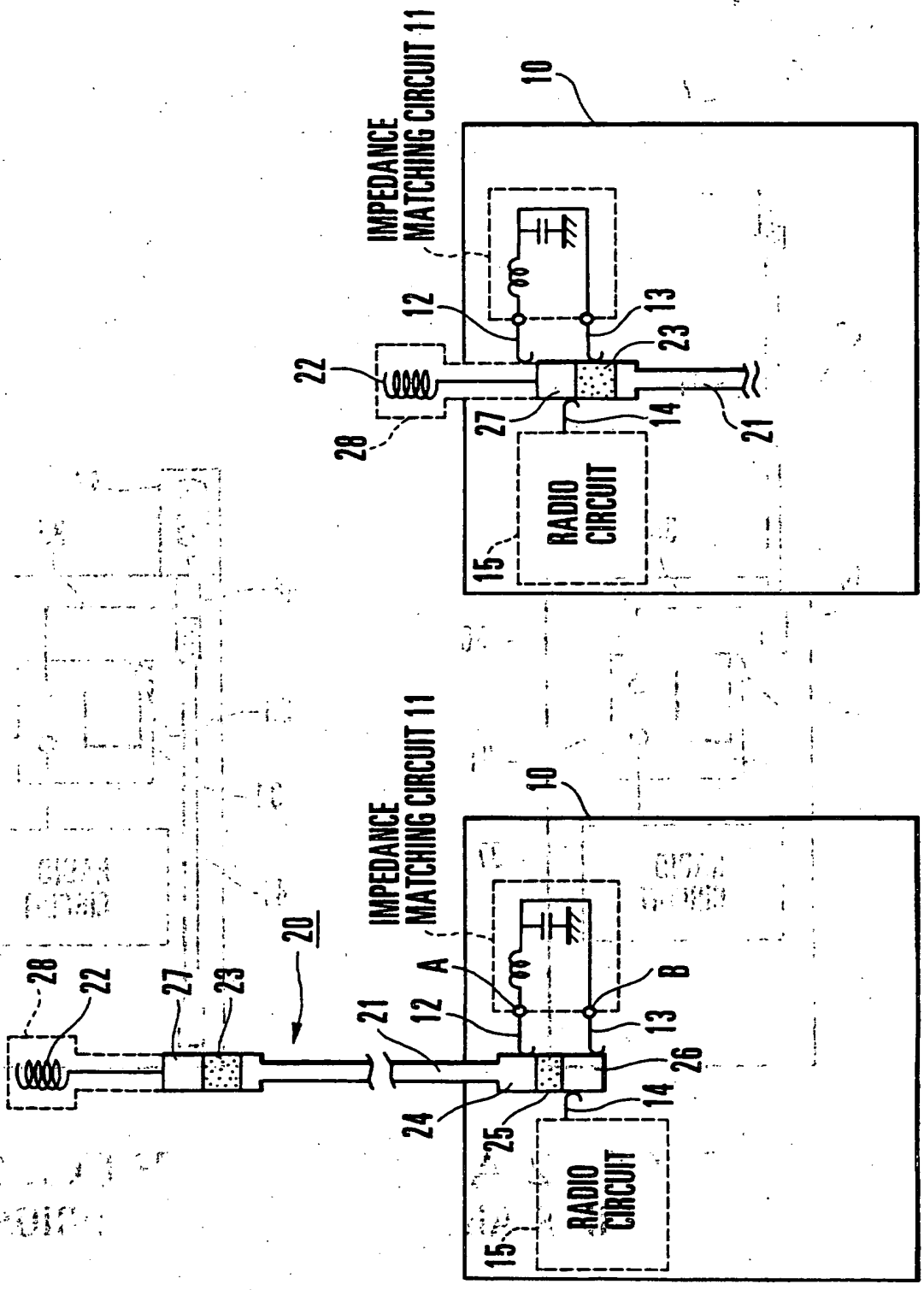
10
IMPEDANCE MATCHING CIRCUIT 11
12
13
22
23
27
14
21
28
RADIO CIRCUIT
15
20
A
B
26
24
25

FIG. 1B

FIG. 1A

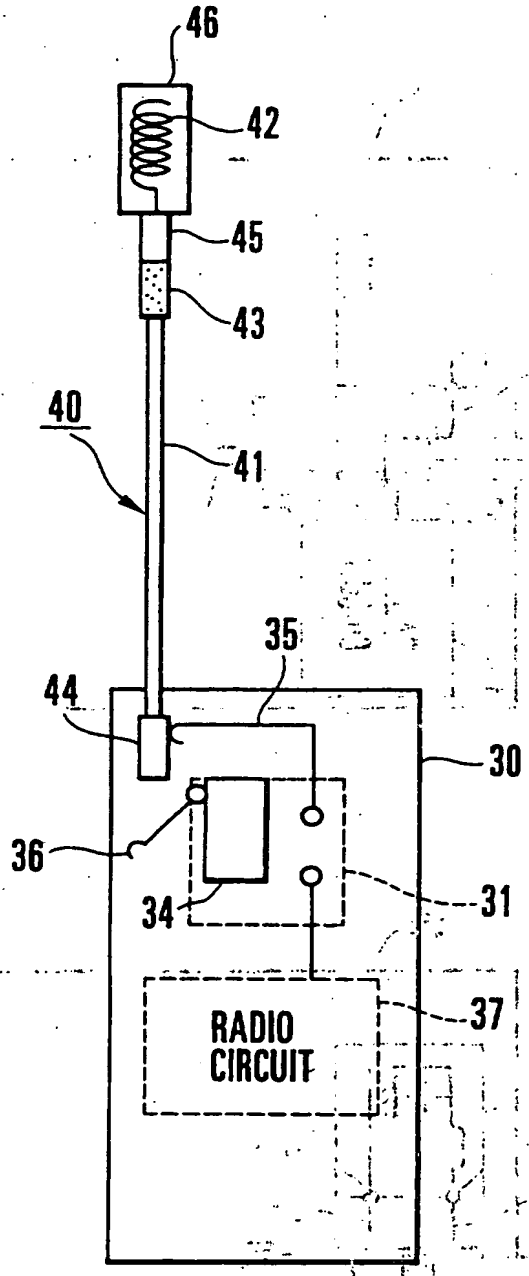

FIG. 2A
PRIOR ART

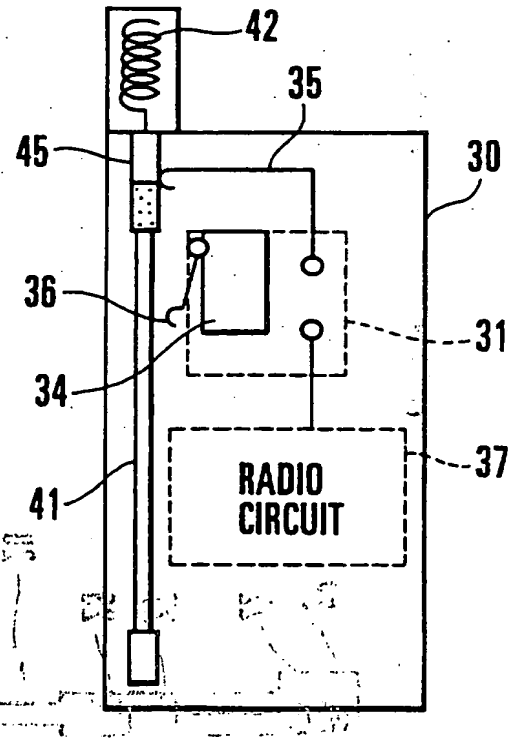

FIG. 2B
PRIOR ART

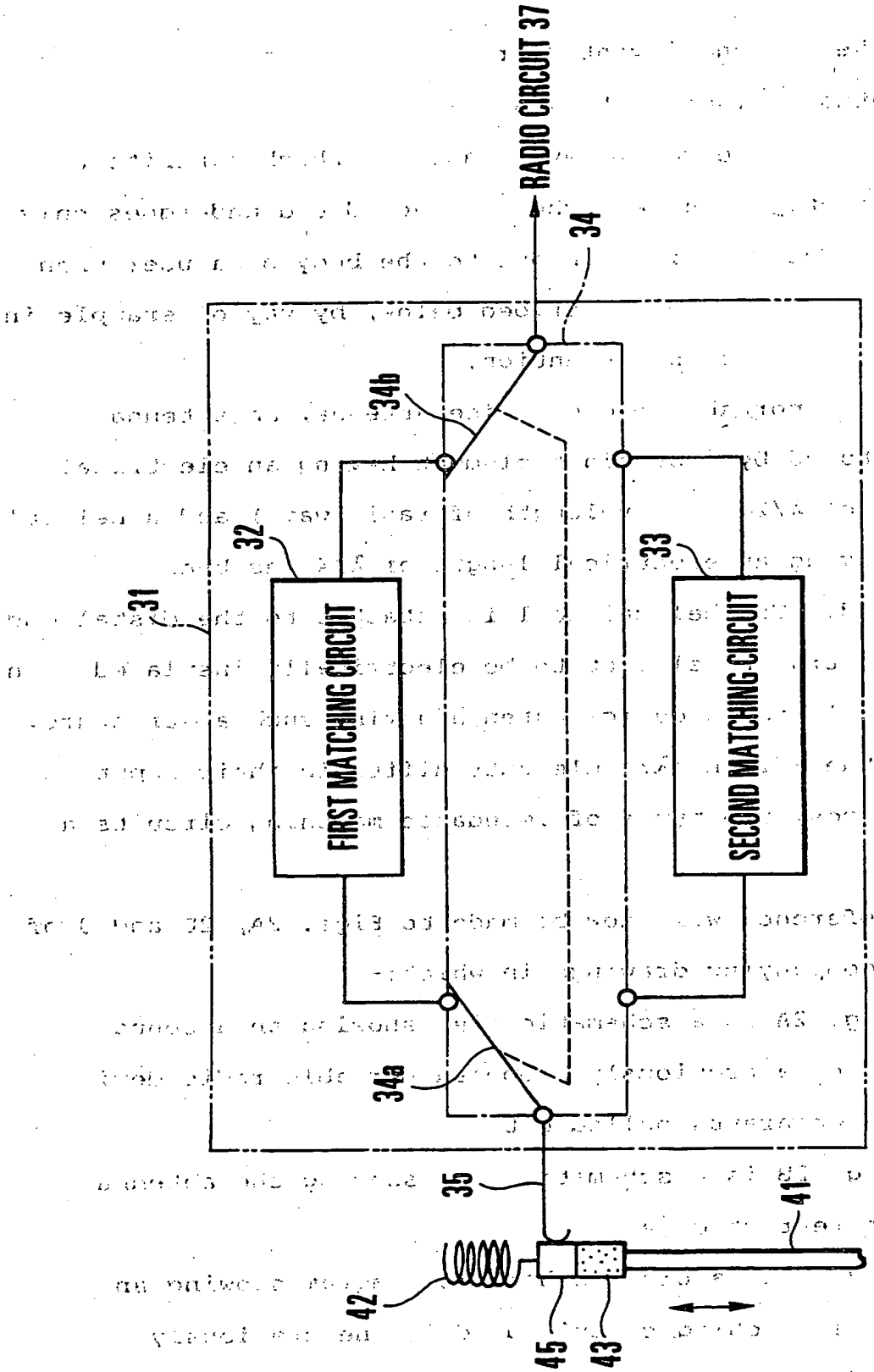

FIG. 3
PRIOR ART

PORTABLE RADIO DEVICE ANTENNA APPARATUS

The present invention relates to an antenna apparatus having a retractable antenna.

A portable radio device antenna which exhibits a sufficiently high gain when retracted and undergoes only a small decrease in gain due to the body of a user when pulled out, will be described below, by way of example in illustration of the invention.

As a portable radio device antenna, an antenna constituted by a straight element having an electrical length of $\lambda/2$ (λ: wavelength of radio wave) and a helical coil having an electrical length of $\lambda/4$ has been proposed. The helical coil is attached to the distal end of the straight element to be electrically insulated. In a portable radio device antenna having such a structure, since the $\lambda/2$ and $\lambda/4$ elements differ in their input impedances, two types of impedance matching circuits are required.

Reference will now be made to Figs. 2A, 2B and 3 of the accompanying drawings in which:-

Fig. 2A is a schematic view showing an antenna element of a previously proposed portable radio device antenna apparatus pulled out,

Fig. 2B is a schematic view showing the antenna element retracted, and

Fig. 3 is a block schematic diagram showing an impedance matching circuit used in the previously proposed portable radio device antenna apparatus shown in

Figs. 2A and 2B.

As shown in Figs. 2A, 2B, and 3, of the accompanying drawings a previously proposed antenna apparatus has a mechanical two-way switch to switch impedance matching circuits depending on whether the antenna is pulled out or retracted. With this structure, two types of impedance matching circuit are switched. That is, as shown in Figs. 2A and 2B, a retractable antenna element 40 is retracted in a casing 30 of a radio device, and an impedance matching circuit 31 is arranged in the casing 30.

As shown in Fig. 3, this impedance matching circuit 31 includes a first matching circuit 32 which operates when the antenna is retracted, a second matching circuit 33 which operates when the antenna is pulled out, and a switch 34 having two-way movable contacts 34a and 34b for switching the first and second matching circuits 32 and 33. A conductive connection metal piece 35 is connected to one terminal of the impedance matching circuit 31, and a radio circuit 37 is connected to the other terminal of the impedance matching circuit 31. The switch 34 has an actuator 36 which operates when an antenna element 40 is retracted in the casing 30.

The antenna element 40 is constituted by a straight element 41 and a helical coil 42 which are coupled to each other through an insulator 43. A conductive connection metal fixture 44 is attached to the lower end of the straight element 41. A conductive connection

metal fixture 45 is attached to the lower end of the helical coil 42. A protective cover 46 covers the helical coil 42.

As shown in Fig. 2A, in this portable radio device antenna, when the antenna element 40 is pulled out from the casing 30, the actuator 36 of the switch 34 is set in a non-contact state, and the movable contacts 34a and 34b are connected to the second matching circuit 33. When the antenna element 40 is retracted in the casing 30, the straight element 41 operates the actuator 36 of the switch 34 to switch the switch 34 so as to connect the movable contacts 34a and 34b to the first matching circuit 32.

However, since the above previously proposed portable radio device antenna uses the mechanical switch having the two movable contacts, the casing 30 needs to have a large volume. A reduction in size of the portable radio device cannot therefore be attained.

Although the present applicant has proposed a portable radio device antenna in Japanese Patent Laid-Open No. 6-232614, this proposed portable radio device antenna has no impedance matching circuit. Other techniques associated with antennas have been disclosed in Japanese Patent Laid-Open Nos. 4-196907, 54-52450, 2-19004, and 64-90604.

Features of a portable radio device antenna apparatus to be described below as examples in illustration of the invention are that it serves as a

straight element having an electrical length of $\lambda 2$, exhibits a sufficiently high gain as a helical coil having an electrical length of $\lambda/4$, and enables a portable radio device antenna apparatus of a reduced size to be provided.

In a particular embodiment to be described below, by way of example in illustration of the present invention, a portable radio device antenna apparatus includes a casing of a radio device and a retractable antenna element mounted on the casing, the antenna element having a rod-like, conductive, straight element with an electrical length of $\lambda/2$, a helical coil with an electrical length of $\lambda/4$ and attached to an outer end of the straight element, an insulator for insulating the straight element from the helical coil, a short-circuit metal fixture mounted on an inner end of the straight element and insulated therefrom, a first contact metal fixture mounted on an inner end of the helical coil and electrically connected to the helical coil, and an insulating protective cover covering the helical coil, the casing including an impedance matching circuit having a pair of terminals and serving to provide impedance matching of the straight element, outer and inner connection metal pieces connected respectively to a pair of terminals of the impedance matching circuit, and a feeding metal piece connected to a radio circuit for transmitting/receiving a radio signal, wherein when the straight element is pulled out from the casing, the

feeding metal piece and the inner connection metal piece are simultaneously connected to the short-circuit metal fixture, and the outer connection metal piece is brought into contact with the straight element, and when the straight element is retracted in the casing, the feeding metal piece is brought into contact with the first contact metal fixture, and the inner and outer connection metal pieces are respectively brought into contact with the insulator and the protective cover.

An arrangement, illustrative of the invention, will now be described, by way of example, with reference to the accompanying drawings, in which:-

Fig. 1A is a schematic view showing an antenna element of a portable radio device antenna apparatus pulled out of the apparatus, and Fig. 1B is a schematic view showing the antenna element retracted into the apparatus.

Referring to Fig. 1A, reference numeral 10 denotes the casing of a portable radio device on which a retractable antenna element 20 is mounted. This antenna element 20 includes a rod-like, conductive, straight element 21 having an electrical length of $\lambda/2$ and a helical coil 22 mounted on the outer end of the straight element 21, incorporating a conductive material, and having an electrical length of $\lambda/4$. The straight element 21 is electrically disconnected from the helical coil 22 as a result of the presence of an insulator 23.

A contact metal fixture 24 is attached to the inner

portion of the straight element 21 and in contact therewith. The contact metal fixture 24 is electrically connected to the straight element 21. A short-circuit metal fixture 26 is mounted on the inner end of the contact metal fixture 24 by means of an insulator 25.

A contact metal fixture 27 is attached to the inner end of the helical coil 22 and in contact therewith. The contact metal fixture 27 is electrically connected to the helical coil 22. The contact metal fixture 27 is mounted on the outer end of the insulator 23 interposed between the straight element 21 and the helical coil 22. The straight element 21 and the contact metal fixture 27 are electrically insulated from each other by the insulator 23. Reference numeral 28 denotes a cap-like protective cover made of a synthetic resin and covering the helical coil 22.

Reference numeral 11 denotes an impedance matching circuit arranged in the casing 10. Connection metal pieces 12 and 13, each made of a conductive metal in the form of a leaf spring, are connected respectively to terminals A and B of the impedance matching circuit 11. The connection metal pieces 12 and 13 are arranged side by side in the axial direction of the antenna element 20. The connection metal piece 12 on the outer side is brought into contact with the antenna element 20. Reference numeral 14 denotes a feeding metal piece made of a conductive metal in the form of a leaf spring and electrically connected to a radio circuit 15. The

feeding metal piece 14 is placed at a middle position between the connection metal pieces 12 and 13, to be in contact with the antenna element 20.

The impedance matching circuit 11, the connection metal pieces 12 and 13, and the feeding metal piece 14 are fixed inside the casing 10. The inner or lower portion of the protective cover 28, the contact metal fixture 27, the insulator 23, the contact metal fixture 24, the insulator 25, and the short-circuit metal fixture 26 have columnar shapes with the same diameter, which is larger than the diameter of the straight element 21.

The situation when the antenna element 20 is pulled out from the casing 10 will be described next with reference to Fig. 1A. While the antenna element 20 is pulled out from the casing 10, the feeding metal piece 14 is connected to the radio circuit 15 is in contact with the short-circuit metal fixture 26. At the same time, the connection metal piece 13 is brought into contact with the short-circuit metal fixture 26. The short-circuit metal fixture 26 is connected to the impedance matching circuit 11 through the connection metal piece 13 and the terminal B. The impedance matching circuit 11 is connected to the contact metal fixture 24 of the straight element 21 through the terminal A and the connection metal piece 12. As a result, power is supplied from the radio circuit 15 to the straight element 21 through the short-circuit metal fixture 26, the impedance matching circuit 11, and the contact metal fixture 24.

At this time, the helical coil 22 is electrically insulated from the straight element 21 by the insulator 23 so only the straight element 21 operates as an antenna. Therefore, the antenna element 20 operates as whip antenna consisting of the straight element having an electrical length of $\lambda/2$, but it is not influenced by the helical coil 22.

The situation when the antenna element 20 is retracted into the casing 10 will be described below with reference to Fig. 1B. While the antenna element 20 is retracted into the casing 10, the feeding metal piece 14 connected to the radio circuit 15 is connected to the contact metal fixture 27 connected to the helical coil 22. Since the connection metal piece 12 is brought into contact with the outer surface of the protective cover 28, the terminal A of the impedance matching circuit 11 is electrically insulated from the helical coil 22. Since the connection metal piece 13 is brought into contact with the insulator 23, the terminal B of the impedance matching circuit 11 is electrically insulated from both the helical coil 22 and the straight element 21. At this time, since the straight element 21 and the helical coil 22 are electrically insulated from each other by the insulator 23, only the helical coil 22 operates as an antenna.

In this situation, power is supplied from the radio circuit 15 to the helical coil 22 through the feeding metal piece 14 and the contact metal fixture 27. Note

that since the helical coil 22 has an impedance of about 50 Ω, no impedance matching circuit is required. In addition, since the contact metal fixtures 24 and 27 and the short-circuit metal fixture 26 have the same diameter, no contact failure occurs with respect to the connection metal pieces 12 and 13 and the feeding metal piece 14.

With the portable radio device antenna described above, switching/power feeding of/for the straight element having an electrical length of λ/2 and the helical coil having an electrical length of λ/4 can be performed with a simple structure without using any mechanical switch, thereby realizing a reduction in size of a portable radio device.

It will be understood that, although a particular embodiment, illustrative of the invention has been described by way of example, variations and modifications thereof, as well as other embodiments may be made within the scope of the appended claims.

CLAIMS

1. A portable radio device antenna apparatus including a casing for the radio device and a retractable antenna element mounted on the casing, the antenna element having a rod-like, conductive, straight element with an electrical length of $\lambda/2$ (λ: wavelength of radio wave), a helical coil having an electrical length of $\lambda/4$ and being attached to the outer end of the straight element, an insulator for insulating the straight element from the helical coil, a short-circuit metal fixture mounted on the inner end of the straight element and insulated therefrom, a first contact metal fixture mounted on the inner end of the helical coil and electrically connected to the helical coil, and an insulating protective cover covering the helical coil, and the casing having an impedance matching circuit with a pair of terminals and serving to match the impedance of the straight element, outer and inner connection metal pieces connected respectively to the pair of terminals of the impedance matching circuit, and a feeding metal piece connected to a radio circuit for transmitting/receiving a radio signal, wherein when the straight element is pulled out from the casing, the feeding metal piece and the inner connection metal piece are simultaneously connected to the short-circuit metal fixture, and the outer connection metal piece is brought into contact with the straight element, and when the straight element is

retracted into the casing, the feeding metal piece is brought into contact with the first contact metal fixture, and the inner and outer connection metal pieces are respectively brought into contact with the insulator and the protective cover.

2. An apparatus as claimed in claim 1, wherein each of the outer and inner connection metal piece and the feeding metal piece is made of a conductive metal in the form of a leaf spring.

3. An apparatus as claimed in claim 2, wherein the antenna element includes a second contact metal fixture which is mounted on the inner end of the straight element and electrically connected to the straight element, and with which the outer connection metal piece is brought into contact.

4. An apparatus as claimed in claim 3, wherein the first and second contact metal fixtures and the short-circuit metal fixture have the same diameter, which is larger than the diameter of the straight element.

5. An apparatus as claimed in claim 1, wherein the feeding metal piece is placed at a middle position between the outer and inner connection metal pieces.

6. An apparatus as claimed in claim 1, wherein

when the antenna element is pulled out from the casing, power is supplied from the radio circuit to the straight element through the feeding metal piece, the short-circuit metal fixture, the inner connection metal fixture, the impedance matching circuit, and the outer connection metal fixture.

7. An apparatus as claimed in claim 1, wherein when the antenna element is retracted into the casing, power is supplied from the radio circuit to the helical coil through the feeding metal piece and the first contact metal piece.

8. An apparatus as claimed in claim 1 substantially as described herein with reference to Figs. 1A and 1B of the accompanying drawings.

The Patent Office

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Application No: GB 9626369.4 **Examiner:** Steven Davies
Claims searched: 1-8 **Date of search:** 11 March 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:
UK Cl (Ed.O): H1Q-QHC, QHX, QKC
Int Cl (Ed.6): H01Q-1/08, 1/10, 1/22, 1/24, 9/30 ; H04B-1/38
Other: Online WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A,P	GB 2296603 A (NOKIA)	
A	GB 2213998 A (TECHNOPHONE)	
A	EP 0688060 A1 (GALTRONICS)	
A	US 5446469 (MAKINO)	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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